Catch and Bycatch in the Shark Drift Gillnet Fishery off Georgia and East Florida

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Introduction

Personnel of the Panama City Laboratory of the NMFS Southeast Fisheries Science Center began work in March 1992 to estimate marine mammal bycatch in directed gillnet fisheries for sharks along the U.S. south Atlantic coast. This study was necessary to meet the intent of the Marine Mammal Protection Act and the Endangered Species Act and to obtain better data on bycatch and discards in the shark fishery. Two types of shark gill nets, set and drift, were studied. Observations on the set-net fishery were obtained from a single fisherman in 1992 (Trent and Castro[1]).

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ABSTRACT—An observer program of the shark drift gillnet fishery off the Atlantic coast of Florida and Georgia was begun in 1993 to define the fishery and estimate bycatch including bottlenose dolphin, Tursiops truncatus, *and sea turtles. Boats in the fishery were 12.2–19.8 m long. Nets used were 275–1,800 m long and 3.2–4.1 m deep. Stretched-mesh sizes used were 12.7–29.9 cm. Fishing trips were usually <18 h and occurred within 30 n.mi. of port. Fishing with an observer aboard occurred between Savannah, Ga., and Jacksonville, Fla., and off Cape Canaveral, Fla. Nets were set at least 3 n.mi. offshore. Numbers of boats in the fishery increased from 5 in 1993 to 11 in 1995, but total trips decreased from 185 in 1994 to 149 in 1995. During 1993–95, 48 observer trips were completed and 52 net sets were observed. No marine mammals were caught and two loggerhead turtles, Caretta caretta, were caught and released alive. A total of 9,270 animals (12 shark, 21 teleost, 4 ray, and 1 sea turtle species) were captured. Blacknose,* Carcharhinus acronotus*; Atlantic sharpnose,* Rhizoprionodon terraenovae*; and blacktip shark,* C. limbatus*), were the dominant sharks caught. King mackerel,* Scomberomorus cavalla*; little tunny,* Euthynnus alleteratus*; and cownose ray,* Rhinoptera bonasus, *were the dominant bycatch species. About 8.4% of the total catch was bycatch. Of the totals, 9.4% of the sharks and 37.3% of the bycatch were discarded.*

Vessels in the shark drift gillnet fishery in 1992–95 had been and are presently engaged in other fisheries. In the 1970's and early 1980's, winter had traditionally been the prime fishing season for these boats. The vessels normally set gill nets around schools of king mackerel, *Scomberomorus cavalla*; Spanish mackerel, *S. maculatus*; bluefish, *Pomatomus saltatrix*, and occasionally for sharks, from November through March. Some vessels also set large-mesh drift nets for sharks from October through April before and after the mackerel seasons (Schaefer et al., 1989; Parrack et al., 1992). By 1987, many of the vessels were driftnetting for king mackerel during April–September to compensate for their reduced winter fisheries. In 1990, the king mackerel driftnet fishery was closed and more of the fishermen began driftnetting for sharks during the warmer months.

In 1990, 11 shark driftnet vessels were operating between Cape Canaveral and Jacksonville, Fla., using gill nets from 650 to 1,450 m long, 20 m deep, and with stretched mesh sizes from 20.0 to 31.0 cm (Read, 1994). Almost nothing was known of the incidental catches made by this fishery but it was thought to probably take cetaceans during fishing operations. NMFS listed bottlenose dolphin, *Tursiops truncatus*, as the only species taken and classified the shark fishery in category III (Douglas, 1989). Because of the apparent similarity of the shark drift gillnet fishery to the U.S. swordfish fishery, the shark fishery was later reclassified as category II (Fox, 1990).

Presently the shark fisheries of the western North Atlantic, including the Gulf of Mexico and the Caribbean Sea, are managed under the Fishery Management Plan for Sharks (NMFS, 1993). For management purposes, the species are divided into pelagic, large coastal, and small coastal groups. About 12 species of the latter two groups are caught in the shark drift gillnet fishery. The large coastal group was managed under a quota (968 metric tons (t) dressed weight in 1995); no quotas applied to the small coastal group.

This report describes for the shark drift gillnet fishery: 1) boats, gear, and fishing methods, 2) methods used in the observer study, 3) shark catch and bycatch, including marine mammals and turtles, related to area and time of year, and 4) discusses the findings in relation to bycatch of bottlenose dolphin in drift nets and other fishing gear.

Fishery Description

Study Area

During the study we observed fishing between Ossabaw Island, just south

[1] Trent, L., and J. Castro. 1993. Descriptions of shark drift net and set gill net fisheries, and observations in a set gill net fishery. Panama City Lab., Southeast Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Panama City, Fla., Unpubl. Rep., 19 p.

of Savannah, Ga., and about 15 n.mi. south of Jacksonville, Fla. (Areas 1, 2); and from New Smyrna Beach to about 10 n.mi. south of Cape Canaveral, Fla., (Area 3–Fig. 1). Except for sets made during movement from one port to another, boats fishing Areas 1–2 departed from St. Marys, Ga., and those fishing in Area 3 departed from Port Canaveral, Fla.

Boats

Boats in the shark drift gillnet fishery were also used in the king mackerel driftnet fishery off Ft. Pierce and Port Salerno, Fla., during the mid to late 1980's (Schaefer et al., 1989). The boats, 12.2–19.8 m long, were modified only slightly to accommodate the drift nets used for shark fishing and were made of either fiberglass or wood covered by fiberglass (Fig. 2). Common to all the shark vessels were diesel engines and hydraulic-powered net retrieval systems composed of a hydraulic roller, a free roller, and a net guidance system.

Nets

The boats carried sections of net 275–1,800 m long and 3.2–4.1 m deep. Two or three sections, each with a different stretched mesh size (12.7–27.9 cm), were often carried so that different sized sharks could be targeted, or so that more webbing could be added when sharks were not abundant. Individual nets varied greatly because they were often pieced together from other nets of various specifications. Nets carried by the boats averaged 821 m long in Areas 1–2 and 270 m long in Area 3, based on estimates provided by the captains.

Nylon twine sizes in the nets ranged from #21 (1.65 mm diameter) to #36 (2.16 mm diameter) for multifilament and #208 (0.52 mm diameter) and #277 (0.57 mm diameter) for monofilament. The nets were weighted with 0.6–0.8 kg/m of leadline and had floats 7.6–15.2 cm long by 7.6–15.2 cm diameter every 0.6–1.1 m. These amounts of weight and flotation reduced the number of sharks rolling up in the webbing and was thought to reduce bycatch by increasing the tautness of the webbing. When floats were smaller than the mesh size being used in the net, a panel with smaller mesh was hung (0.9–1.3 m deep) from the floatline to keep floats from passing through the meshes and tangling during deployment.

A battery powered strobe light was attached to each end of the net, and sometimes in the middle, to allow fishermen to locate their net and to alert other boats to the presence of a net. On all boats observed, the captain or a crew member kept watch on vessel activity in the area during the drift.

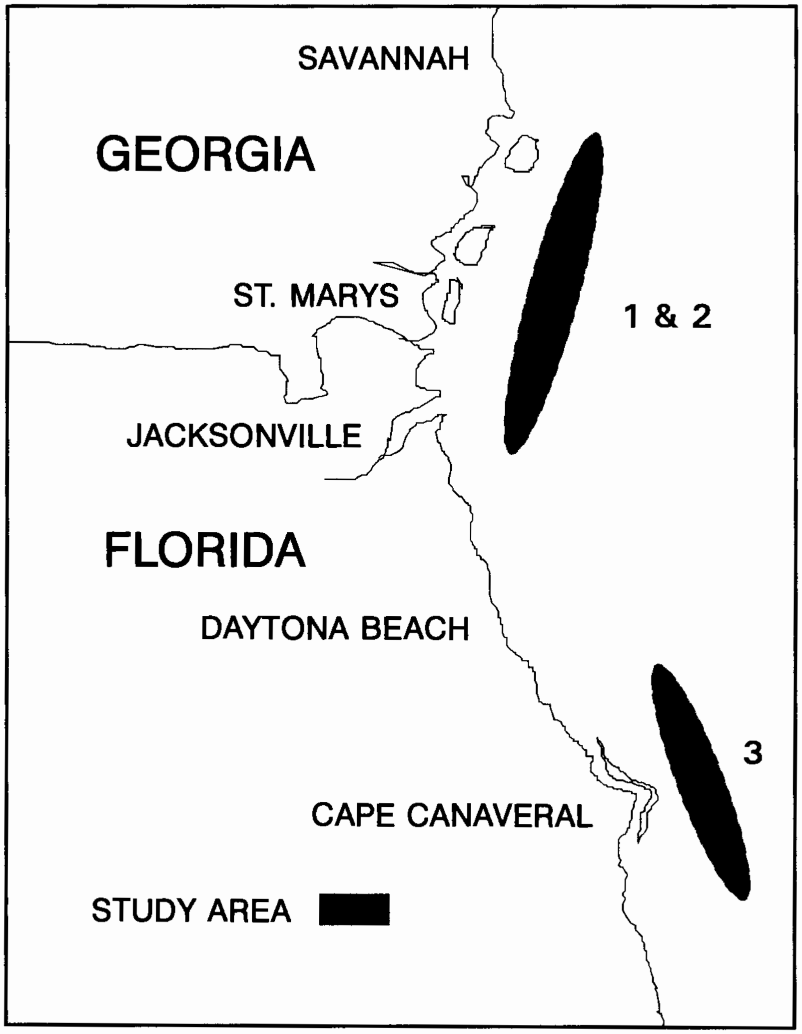

Figure 1.—Fishing areas where sets were made and observed.

Locating Sharks

Boat captains used several methods to locate sharks or potential areas of abundance. Spotter pilots were used during daytime to look for concentrations of bait (especially menhaden, *Brevoortia* spp.), schools of sharks in clear water, areas of turbid water, individual sharks rolling or jumping at the surface, and sharks feeding on the bycatch of shrimp boats. Radio communication with captains of shrimp boats fishing within the range of the vessel often provided useful information. Off Cape Canaveral, color depth recorders were used to locate schools of sharks or schools of bait the sharks prey on. If neither could be located, the set was made in a historically productive area.

Sample sets were used for a short time during 1993 to determine if small coastal group sharks were present and to avoid large coastal group sharks that could not be legally landed. Upon arrival in the general fishing area, a short (150–400 m) section of the net was set off the stern and allowed to drift with the boat for 5–30 min, often just behind a shrimp boat culling its catch where bycatch was present in the water. The catch provided information on abundance and species composition of sharks in the area.

Setting Net

The net was usually set in an east to west or west to east direction, depending on currents and winds. Once an area was selected, the captain determined the direction of drift using loran. Changes in the set direction were made often, based on wind direction, so that the boat stayed downwind of the net. The drag of the net in the water served as an anchor to pull the net off the boat. Normally, captains inspected the entire length of the net using a spotlight after setting and every 0.5–2 h thereafter to assess the catch and ensure that the net was fishing properly.

Environmental factors and shark catch per unit of effort (CPUE) determined how long the net was left drifting, with the latter being the major determinant. When CPUE was high, the net was run at intervals as short as 20 min. Extreme changes in wind and sea states prevented the net from drifting properly and precluded checking the net. Under extreme conditions, the net was retrieved without removing the sharks. Wind speeds >15 kn occasionally stalled the power roller. The wind and current together could fold the net into shapes not conducive to high CPUE or easy hauling, particularly when a section of the net made contact with the bottom. The height of the seas was not as limiting to fishing as the frequency and form of the waves.

Hauling the Net

Methods of net retrieval (hauling), catch removal, and shark processing varied among boats and depended on the size of both crew and catch. Hauling began by routing a rope under the lower rollers and back and over the power roller from the stern to the bow. Next, the net was attached to the rope on the stern side and the hydraulic motor engaged thus pulling the net through the rollers. Some boats kept the roller on throughout the haul and removed sharks as they came aboard. Boats using the continuous retrieval method usually had a crew of four or five, with two retrieving and stacking the net ready to redeploy, one or two removing sharks, and one or two dressing them. The net was stopped occasionally during the haul when catch was great or when a shark was difficult to remove.

The net was sometimes retrieved nonstop without removing the catch, a method referred to as "roping in the net." This required handling the net three times; once during hauling, again when the catch was removed, and finally when preparing for redeployment. The free roller was often used to move and reorganize the net on deck.

Processing and Marketing

Sharks were dressed by heading, eviscerating, and removing fins as they came aboard or at the end of the haul. Sharks were put in an ice box or piled, washed, placed on one side of the deck, and iced. A serrated knife was used for removing the fins and tail and for cutting behind the head and gill slits and forward of the pectoral fin. A fleshing knife was inserted at the base of the head cut, drawn back and around the posterior of the anus on both sides thus separating the head, belly, and anus from the carcass. The fins were removed from the shark in a manner which minimized the amount of flesh left on the fin.

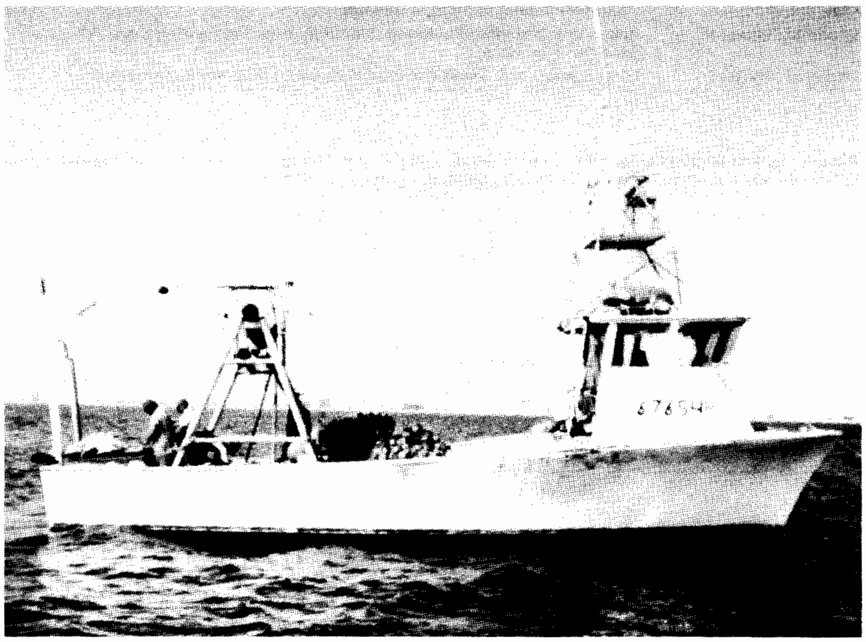

Figure 2.—Shark drift gillnet boats showing nets, power roller system, and fishermen dressing catch.

Methods of Observation and Trip Description

Trips in the shark drift gillnet fishery varied in crew size, duration, and length of sets. Crew size, including the captain, ranged from 3 to 6. The boats left port between 1500 and 1900 h, depending on distance to the fishing grounds. On nights with good catches, net retrieval and processing required up to 8 h. For each set and haul of the net we recorded: beginning and ending times of setting and of hauling, estimated length of net set, sea and wind states, loran coordinates, and water depth. During each set the net was observed from end to end at <2 h intervals. The observer and 1–2 crew members observed the net and catch that could be seen with a spotlight, as the captain ran the boat alongside the net at a speed of about 3 kn. Usually animals >1 m total length could be seen in the net at estimated depths of 5–10 m.

Observations were made as the net was hauled aboard. The observer remained about 8 m forward of the net reel and recorded species, numbers, and estimated weights of sharks and other species caught as they were suspended in the net just after passing over the power roller. When species identification was questionable, the crew stopped the reel so that the observer could examine the animal(s). The weight of each animal was estimated in pounds. Size was, therefore, estimated imprecisely but this was the only way to obtain these data safely and without seriously interfering with the fishing operation.

Catches from 16 of 52 sets were subsampled, allowing rest periods for the observer who may have traveled to the embarking location and to the fishing grounds for 18–24 h without sleep. In these instances the catch of a set (C_s) was estimated as

$$C_s = A_o \times H_t / H_o$$

where, C_s = catch of a set,
A_0 = animals observed,
H_t = total hours of set, and
H_o = observation time in hours.

The number of pounds caught for each set and species were estimated as mean weight of each species caught times the total or estimated total number of each species caught. Overall mean weights for each species were obtained as the sum of mean weights for a species divided by the number of means, i.e. the number of trips the species was caught. CPUE was the number, or pounds, caught divided by the soak time in hours. Catches were not recorded by mesh size, however, all animals were caught in stretched mesh (SM) size ranges of: 20.3–27.9 cm in Areas 1–2, and 12.7–20.3 cm in Area 3. Most nets were composed of unequal size sections with different mesh and twine sizes, and the sections were sometimes haphazardly mixed. CPUE was not calculated by length of net because it was not possible to determine the net length set, and often, after deployment, part of the net would be retrieved, fished, and then reset so that different portions would fish different lengths of time.

Total numbers of successful fishing trips (a trip when the net was set) were estimated from interviews (in person or by telephone) with the boat captain or fish processors, and by direct observation. To evaluate dispositions of the total catch the definitions in Table 1 were used.

Fishing Effort and Observed Effort

Captains would occasionally travel up to 4 hr before selecting a fishing location in Areas 1–2, but in Area 3 the time traveled was usually <1.5 h.

Since driftnet fishing was prohibited in territorial waters of Georgia and Florida, nets were set at least 4.8 km offshore in the Exclusive Economic Zone (EEZ). Shark drift nets were set in waters 4.6–21.0 m deep over bottoms with no known obstructions, and on outgoing tides to prevent the net from drifting into state waters when set near inlets. Nets were sometimes fished offshore of inlets because these areas often had high concentrations of sharks.

Total annual fishing effort decreased during the study. The known number of boats in the shark drift gillnet fishery increased from 5 in 1993 to 11 in 1995; the total number of trips, however, was lower in 1995 than in 1994 (Table 2). Trips per boat averaged 30.8 in 1994 but only 13.5 in 1995. Total fishing effort in Areas 1 and 2 decreased from 61 trips in 1994 to 19 trips in 1995, while Area 3 changed little between years. These changes are probably attributable to the Florida net ban inshore in 1995 (Rivers, 1995), decreased value of shark meat, and quota regulations. Wholesale prices for shark declined in 1995 (Table 2) such that fish processors often requested captains not fish because of low demand for shark meat. Fishing effort also decreased because of landing closures on the Large Coastal sharks when the quotas were reached.

Table 1.—Terms and definitions for catch and disposition

Term	Definition
Total catch	All animals caught (numbers or pounds).
Bycatch (other)	All nonshark species caught.
Directed catch	All sharks caught.
Kept	All animals retained and landed dockside.
Discarded (low value)	Animal or animal carcasses (but not the fins for large hammerhead sharks) discarded because of low value.
Discarded (regulated)	Large coastal group sharks discarded because the quota had been reached.

Table 2.—Estimated total fishing effort by boat, prices paid per pound for shark, and estimated numbers of trips in Georgia (Area 1), north Florida (Area 2), and mid Florida (Area 3) in 1994–95.[1]

	Fishing effort		
Year	Boats	Total trips	No. of successful trips by boat
1994	6	185	31, 30, 48, 32, 30, 14
1995	11	149	12, 12, 10, 22, 14, 18, 6, 14, 15, 18, 8

	Price per pound (Month and dollars per pound dressed weight)				
	May	June	July	Aug.	Sept.
1994	\$0.40–0.60	\$0.45–0.60	\$0.45–0.65	\$0.30–0.60	\$0.40–0.60
1995	\$0.40	\$0.20–0.40	\$0.20–0.30	\$0.25–0.50	\$0.30–0.50

	Number of successful trips	
	Area 1–2	Area 3
1994	61	124
1995	19	130
Total	80	254

[1] Closures for large coastal sharks: 1993, 15 May, 31 July; 1994, 17 May, 10 Aug. (reopened 1 Sept.), 4 Nov.; 1995, 31 May, 30 Sept.

A total of 52 sets on 48 trips were observed during the study (Table 3), but 24 other observer trips were initiated in that the observer traveled to the port of anticipated departure but the trips were aborted before or after departure from the dock. Reasons for these cancellations included bad weather before or after departure, equipment failure, and failure of a full crew to report. Mean soak times for sets on the successful observer trips were: Area 1, 7.5 h; Area 2, 7.7 h; Area 3, 6.7 h.

Results

Observed Catches

An estimated 9,270 animals were caught (all were observed except for those estimated for the nonsampling rest periods (Tables 4, 5)). The catch consisted of 12 species of sharks, 25 species of finfishes and rays, and 1 species of marine turtle. Total estimated numbers caught were 8,142 sharks, 148 rays, 984 finfish, and 2 loggerhead turtles. Eight species made up over 99% (by weight and number) of sharks caught (Table 5, Fig. 3). These 8, in order of abundance by weight, were blacknose, Atlantic sharpnose, blacktip, finetooth, scalloped hammerhead, bonnethead, spinner, and great hammerhead. Blacknose and Atlantic sharpnose in the Small Coastal group, and blacktip, in the Large Coastal group, dominated overall catches, and there were small differences in catches by species among areas; most abundant by weight were blacknose and blacktip in Areas 1 and 2 and Atlantic sharpnose in Area 3 (Fig. 4).

Ten species of finfish and rays made up over 97% by weight of the nonshark species, and there were some differences in species numbers by area. The order of abundance in catches overall was king mackerel, little tunny, cownose ray, crevalle jack, cobia, spotted eagle ray, great barracuda, tarpon, Atlantic stingray, and Spanish mackerel (Fig. 3). The bycatch was dominated by different species in different areas. In Georgia, cownose ray, crevalle jack, cobia, and the spotted eagle ray were most abundant in the bycatch; in north Florida, cownose ray and spotted eagle ray were dominant (Fig. 5), and in mid

Table 3.—Observed fishing effort (soak time or ST) in relation to year and area for each trip (trip number or TN), and haul (haul number or HN).

	Area 1			Area 2			Area 3		
Year	TN	HN	ST	TN	HN	ST	TN	HN	ST
1993	3	1	4.5	5	1	3.6	6	1	1.5
	4	1	5.8				6	2	2.2
1994	5	1	7.2	6	1	8.5	1	1	9.0
	7	1	8.3	11	1	5.7	2	1	9.8
	8	1	8.7	13	1	9.7	3	1	8.4
	12	1	8.0	14	1	9.6	4	1	9.4
	15	1	8.0	15	1	8.0	9	1	7.5
	16	1	9.8	22	1	8.6	10	1	4.7
	21	1	9.9				17	1	10.4
	25	1	9.6				19	1	7.5
	26	1	8.6				20	1	8.2
	27	1	6.7				23	1	8.7
							28	1	7.1
							29	1	6.0
							34	1	4.2
							36	1	1.5
							36	2	6.5
							37	1	4.3
							38	1	11.8
							41	1	4.1
							41	2	5.8
							43	1	6.0
							44	1	3.3
							44	2	4.9
							47	1	8.6
							48	1	12.1
1995	5	1	4.2				1	1	4.2
	6	1	6.0				2	1	10.9
							3	1	5.9
							4	1	8.1
							10	1	5.4
			105.3			53.7			208.0

Table 4.—List of shark and bycatch species caught in order of decreasing abundance in the observed catches.

Abbreviation	Common name	Scientific name
Sharks		
BKNS	Blacknose	*Carcharhinus acronotus*
ATSH	Atlantic sharpnose	*Rhizoprionodon terraenovae*
BTIP	Blacktip	*Carcharhinus limbatus*
FTTH	Finetooth	*C. isodon*
SCHA	Scalloped hammerhead	*Sphyma lewini*
BTHD	Bonnethead	*S. tiburo*
SPIN	Spinner	*Carcharhinus brevipinna*
GRHA	Great hammerhead	*Sphyma mokarran*
SBAR	Sandbar	*Carcharhinus plumbeus*
BULL	Bull	*C. leucas*
LEMN	Lemon	*Negaprion brevirostris*
TIGR	Tiger	*Galeocerdo cuvieri*
Bycatch		
KMAC	King mackerel	*Scomberomorus cavalla*
LTUN	Little tunny	*Euthynnus alleteratus*
CNSR	Cownose ray	*Rhinoptera bonasus*
CREV	Crevalle jack	*Caranx hippos*
COBI	Cobia	*Rachycentron canadum*
SPER	Spotted eagle ray	*Aetobatus narinari*
BARA	Great barracuda	*Sphyraena barracuda*
TARP	Tarpon	*Megalops atlanticus*
ASRY	Atlantic stingray	*Dasyatis sabina*
SMAC	Spanish mackerel	*Scomberomorus maculatus*
ATMA	Atlantic manta ray	*Manta birostris*
BETU	Bigeye tuna	*Thunnus obesus*
BLTU	Blackfin tuna	*Thunnus atlanticus*
GTOP	Gafftopsail catfish	*Bagre marinus*
BFSH	Bluefish	*Pomatomus saltatrix*
ABON	Atlantic bonita	*Sarda sarda*
TRIP	Tripletail	*Lobotes surinamensis*
SPAD	Spadefish	*Chaetodipterus faber*
MOON	Atlantic moonfish	*Selene septapinnus*
AMEN	Atlantic menhaden	*Brevoortia tyrannus*
BRUN	Blue runner	*Caranx chrysops*
UFIL	Unicorn filefish	*Fluterus monoceros*
LDWN	Lookdown	*Selene vomer*
FPOM	Florida pompano	*Trachyinotus carolinus*
REMO	Remora	*Remora remora*
LOHE	Loggerhead sea turtle	*Caretta caretta*

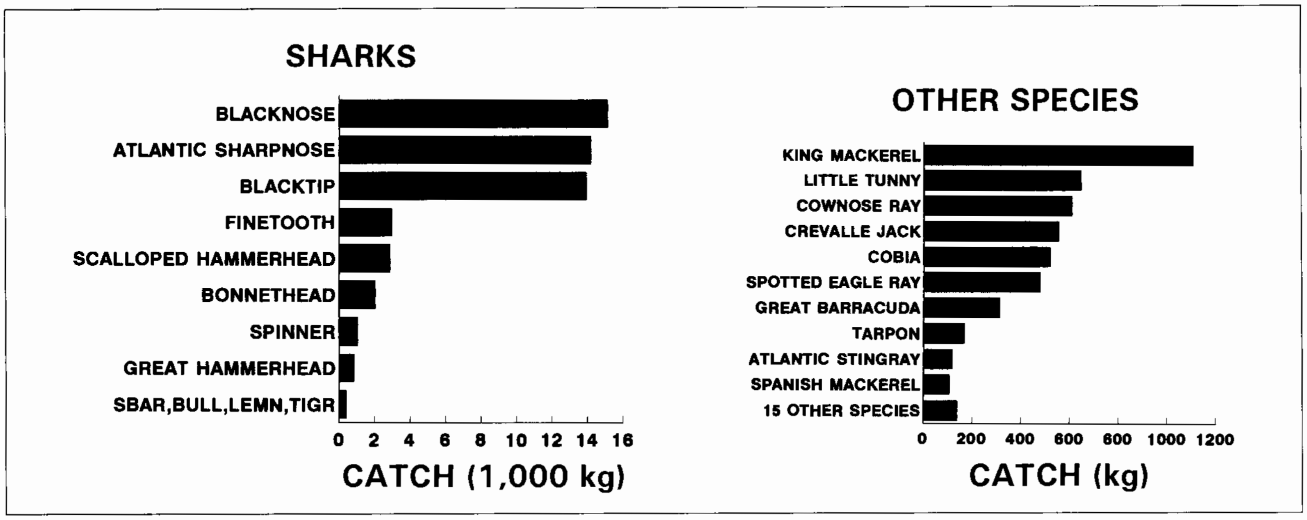

Figure 3.—Kilograms caught by species in relation to group during observer trips. SBAR = sandbar, BULL = bull, LEMN = lemon, and TIGR = tiger.

Table 5.—Number and total catch (kg) by species and area for all species counted during all observer trips.

	Number caught and weight (kg)							
	Area 1–3		Area 1		Area 2		Area 3	
Species	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Sharks								
Blacknose	1,652	15,115	1,110	10,516	456	3,977	86	621
Atlantic sharpnose	4,254	14,171	153	559	151	402	3,930	13,210
Blacktip	1,138	13,914	585	8,578	140	2,862	413	2,473
Finetooth	320	2,946	202	2,306	18	227	100	413
Scalloped hammerhead	137	2,861	39	1,348	41	1,032	57	481
Bonnethead	555	2,022	333	1,325	30	187	192	510
Spinner	63	1,032	19	330	41	690	3	13
Great hammerhead	16	823	0	0	0	0	16	823
Sandbar	3	150	0	0	1	95	2	54
Bull	2	159	1	0	1	159	0	0
Lemon	1	91	1	91	0	0	0	0
Tiger	1	6	0	0	0	0	1	6
Subtotal	8,142	53,290	2,443	25,053	879	9,631	4,800	18,604
Bycatch								
King mackerel	299	1,103	2	16	2	16	293	1,070
Little tunny	309	643	6	10	16	35	285	597
Cownose ray	82	606	61	334	8	107	13	165
Crevalle jack	116	554	90	518	2	12	24	24
Cobia	39	518	11	316	2	25	24	177
Spotted eagle ray	25	477	21	350	3	116	1	11
Great barracuda	52	312	3	14	0	0	49	298
Tarpon	6	166	5	134	1	32	0	0
Atlantic stingray	34	117	4	7	0	0	30	110
Spanish mackerel	102	106	2	1	2	3	98	102
Atlantic manta ray	7	53	0	0	2	6	5	47
Bigeye tuna	3	27	0	0	0	0	3	27
Blackfin tuna	1	14	0	0	0	0	1	14
Gafftopsail catfish	11	9	0	0	0	0	11	9
Bluefish	5	7	0	0	0	0	5	7
Atlantic bonita	3	6	0	0	2	4	1	3
Tripletail	1	5	0	0	0	0	1	1
Spadefish	2	4	1	1	1	4	1	1
Atlantic moonfish	1	2	0	0	0	0	1	2
Atlantic menhaden	15	2	4	1	0	0	2	1
Blue runner	11	2	0	0	0	0	2	2
Unicorn filefish	2	2	0	0	0	0	3	1
Lookdown	4	1	1	1	0	0	4	1
Florida pompano	1	1	0	0	0	0	3	1
Remora	1	2	0	0	0	0	1	2
Subtotal	1,132	4,739	211	1,703	41	360	862	2,673
Loggerhead sea turtle	2	160	2	160	0	0	0	0
Grand total	9,276	58,187	2,654	29,916	920	9,991	5,662	21,277

Florida, king mackerel and little tunny were dominant. These six species comprised over 82% by weight of the total bycatch.

The largest animals by weight caught during observer trips were; bull, lemon, and sandbar sharks, the Atlantic manta ray, and loggerhead turtles (Table 6). In general, animals caught in Areas 1 and 2 were larger than those in Area 3, probably because smaller mesh sizes were used in the latter area.

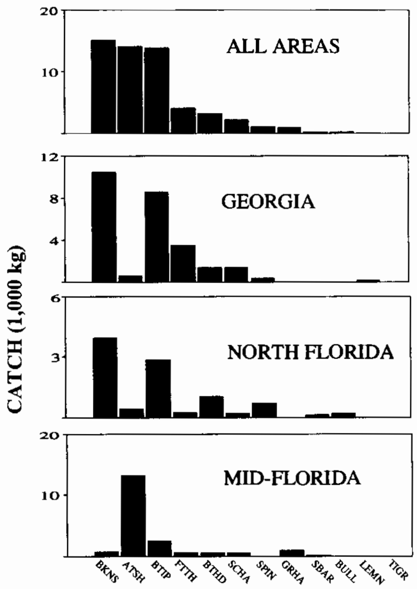

Figure 4.—Kilograms of sharks caught by species and area during observer trips.

Bycatch mortality varied among species. Loggerhead turtles and most rays (spotted eagle, cownose, and manta) were alive when released, while most king mackerel, Spanish mackerel, and barracuda were dead or near so when brought aboard.

Catch Disposition

Portions of both the directed catch (sharks) and bycatch were discarded. Of the total observed catch, about 8.4% (4,739 kg of 58,187 kg) (Table 5) was bycatch (Fig. 6); 9.4% of sharks and 37.3% of the bycatch were discarded. Bycatch in each area, as part of total catch, was greatest (12.3%) in Area 3 and least (3.6%) in Area 2 (Fig. 7). The proportions discarded varied among directed and bycatch groups and among areas (Fig. 7). In the directed catch the highest amount (11.8%) discarded was in Area 1, and least (3.7%) in Area 3. For bycatch the highest proportion (85.7%) was discarded in Area 2, and least (17.9%) in Area 3.

Number of pounds discarded relative to number of pounds kept (discard ratios, Alverson et al., 1994) were determined for sharks only and for shark discards plus all other discards (Table 6), and the ratios varied among areas. Discard ratios for sharks were highest (0.14) in Area 1 where the highest weight of large coastal sharks (mostly blacktip and scalloped hammerhead) were discarded because of quota regulations. Overall (shark plus other bycatch) discard ratios were lowest (0.04) in Area 3 because low numbers of large coastal sharks were caught and because much of the bycatch was king mackerel that were kept.

Disposition and abundance of components of the total catch varied among areas (Table 7 and Fig. 7). In Area 1, percent of nonvalue discards of sharks (mostly carcasses of large hammerheads after fins were removed) was low (2.4%), whereas percent of high value species (blacktip and bull) that were illegal to land after the quota had been reached was high (11.1%). For bycatch in Area 1 over half was discarded; king mackerel, little tunny, crevalle jack, cobia, and great barracuda were kept. In Area 2, nonvalue discards (scalloped hammerhead) and animals illegal to land (blacktip and spinner) made up equal portions of the shark discards. Most of the nonshark bycatch in Area 2 was discarded. Area 3 had the smallest percentages of discards in both shark and nonshark groups.

CPUE's (kilograms caught per net hour of soak time) for sharks by area were: Area 1, 249 kg; Area 2, 179 kg; and Area 3, 89 kg. Highest CPUE by species was: blacknose, 41 kg; Atlantic sharpnose, 39 kg; and blacktip, 38 kg (Table 8).

Different species of coastal pelagics were dominant in the 3 areas (Table 8,

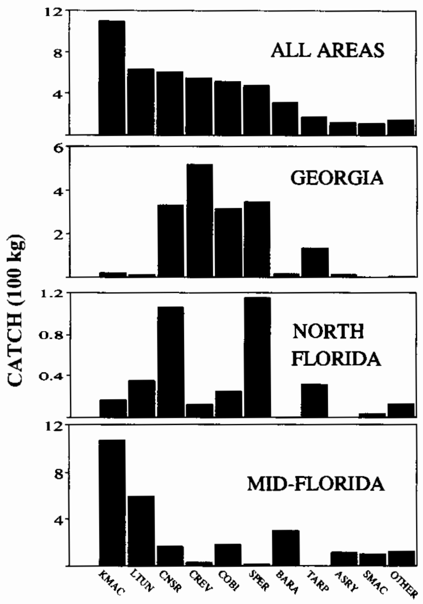

Figure 5.—Kilograms of nonshark bycatch caught by species and area during observer trips.

Table 6.—Mean weight (kg), kilograms kept, and kilograms discarded by species during the observer trips

	Weight (mean, kept, discarded)								
	Area 1			Area 2			Area 3		
Species	Mean	Kept	Disc.	Mean	Kept	Disc.	Mean	Kept	Disc.
Sharks									
Blacknose	8.8	10,516	0	7.4	3,977	0	7.1	616	5
Atlantic sharpnose	3.1	559	0	2.8	402	0	2.6	13,175	35
Blacktip	14.1	6,034	2,544	17.7	2,521	340	12.4	2,437	36
Finetooth	9.0	2,306	0	13.6	227	0	3.2	409	4
Scalloped hammerhead	32.3	795	553	23.0	637	395	17.5	356	125
Bonnethead	4.2	1,325	0	5.6	187	0	2.3	503	7
Spinner	18.0	330	0	17.2	636	54	3.7	13	0
Great hammerhead		0	0		0	0	47.9	356	467
Sandbar		0	0	95.3	95	0	27.2	54	0
Bull	13.6	0	14	159.0	159	0		0	0
Lemon	90.8	91	0		0	0		0	0
Tiger		0	0		0	0	4.5	6	0
Subtotal		21,956	3,111		8,841	789		17,925	679
Bycatch									
King mackerel	7.9	10	5	53.6	16	0	4.8	1,025	45
Little tunny	1.7	10	0	2.4	7	28	2.6	595	2
Cownose ray	4.6	0	334	10.1	0	107	5.7	0	165
Crevalle jack	8.0	463	54	6.1	3	9	1.0	24	0
Cobia	23.1	224	93	16.8	24	0	5.9	136	42
Spotted eagle ray	20.1	0	350	30.6	0	116	11.3	0	11
Great barracuda	6.8	14	0		0	0	6.6	256	42
Tarpon	25.0	0	134	31.8	0	32		0	0
Atlantic stingray	1.9	0	7		0	0	3.7	0	110
Spanish mackerel	0.4	0	1	1.6	0	3	1.1	102	0
Atlantic manta ray		0	0	2.9	0	6	121.2	0	47
Bigeye tuna		0	0		0	0	9.1	27	0
Blackfin tuna		0	0		0	0	13.6	14	0
Gafftopsail catfish		0	0		0	0	0.8	4	5
Bluefish		0	0		0	0	1.4	7	0
Atlantic bonita		0	0	1.6	0	4	2.7	3	0
Tripletail	2.7	5	0		0	0	0.4	1	0
Spadefish	0.4	0	1	3.6	0	4	0.2	0	1
Atlantic moonfish		0	0		0	0	0.3	1	1
Atlantic menhaden	0.1	0	1		0	0	0.3	1	1
Blue, runner		0	0		0	0	0.6	0	2
Unicorn filefish		0	0		0	0	0.4	0	1
Lookdown	0.4	0	1		0	0	0.1	1	0
Florida pompano		0	0		0	0	0.4	1	0
Remora		0	0		0	0	1.8	0	2
Subtotal		726	980		50	309		2,198	477
Loggerhead sea turtle	175	0	159		0	0		0	0
Grand total		22,682	4,250		8,891	1,098		20,123	1,156

Fig. 8). Species with highest CPUE were cobia in Area 1, little tunny in Area 2, and king mackerel in Area 3. CPUE of king mackerel and little tunny were much higher in Area 3 than in the other two areas.

Sizes of the catches of coastal pelagics by species are shown in Figure 9. Catch-frequency distributions indicated that, when a coastal pelagic species was caught in a set, the most frequently occurring size of the catch was 51–100 kg for king mackerel, 0–20 kg for little tunny, and 21–50 kg for cobia (Fig. 9). The number of sets that had catch of over 300 kg were 2 for king mackerel, and 1 for both little tunny and cobia.

Discussion

Little is known about the bycatch mortality inflicted by the many coastal fisheries along the Atlantic states because bycatch has not been documented. Bottlenose dolphin mortalities suspected of being caused by fishing along the coastal states are provided in Table 9 and in relation to specific fisheries in Table 10. Marine mammal stranding records collected during 1988–93 showed an average of 21 stranded bottlenose dolphins per year in the area from North Carolina to the Florida Keys that were thought to have been killed by fishing; signs of human interaction included net marks, net or line entanglement, gunshot wounds, and boat propeller strikes (Blaylock et al., 1995). Rough estimates of annual mortality on bottlenose dolphin by the swordfish drift gillnet and by the Atlantic swordfish/tuna/shark pair trawl fisheries were each over 50 per year during 1991–93 (Table 10).

The swordfish and shark drift gillnet fisheries along the U.S. Atlantic coast were described as being similar in regard to threats to marine mammals (Read, 1994). The swordfish driftnet fishery is classified as a Category I fishery (Tillman, 1991) based on factual information on marine mammal kills. Between August and December 1989, 44 cetaceans were killed during 54 sets based on observations by NMFS observers. The number of animals killed per set varied from 0 to 12; at least one cetacean was killed in almost half of the observed sets, but few sets killed more than two. Between January 1990 and December 1992, 208 sets were observed and a mean bycatch per set of 1.35 was recorded. Read (1994) concluded that the incidental takes in this fishery were high enough to pose a potential threat to several cetacean populations. Cetacean species caught, in decreasing order, were common dolphin, bottlenose dolphin, Risso's dolphin, beaked whale, *Mesoplodon* spp., pilot whale, *Globicephala* spp.; and spotted, striped, and spinner dolphins, *Stenella* spp. One bottlenose dolphin was killed in 63.5 net days (24 h of fishing by a 100 m long anchored gill net) of fishing, that had catches observed, in April–October 1992 in a set-net shark fishery off South Carolina (Trent and Castro[1]).

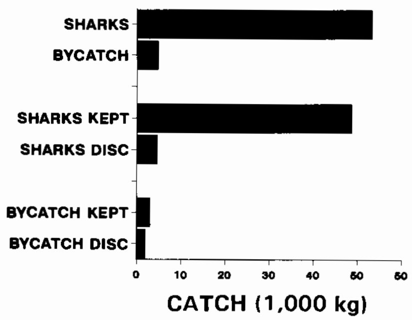

Figure 6.—Total catch and disposition of catch during observer trips.

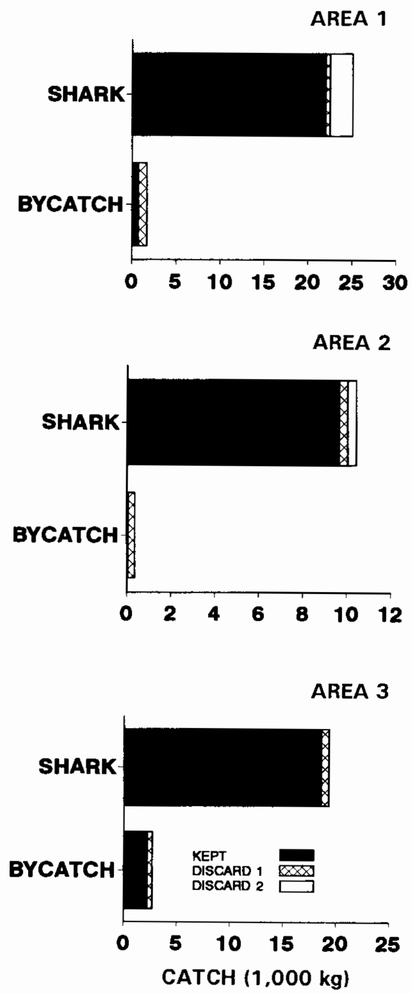

Figure 7.—Disposition of catch in relation to species group and area for observer trips.

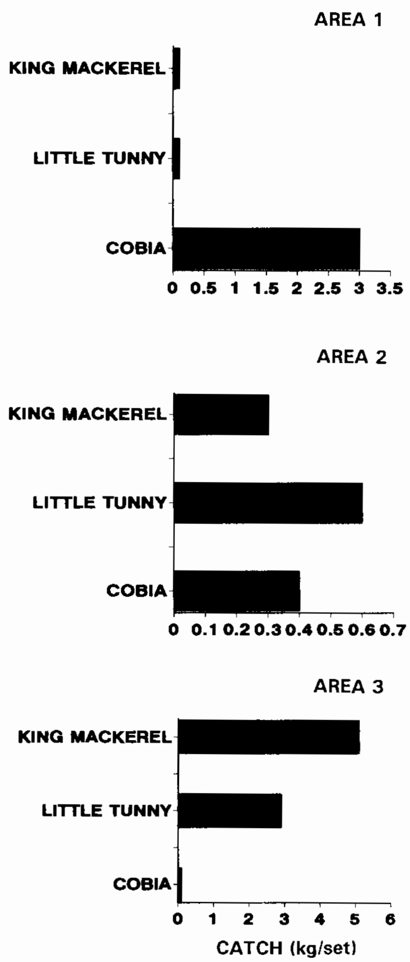

Figure 8.—Kilograms caught per set of the more abundant coastal pelagic species by area for observer trips.

The shark drift gillnet fishery was classified as a Category II fishery (Fox, 1990) because it was thought to operate in a fashion similar to the swordfish driftnet fishery, but observer information was needed to determine if a Category I classification was justified. Bycatch in the two fisheries were not similar, however. Bottlenose dolphin were not caught during this study, nor at night did we observe them in the vicinity of or caught in the net during frequent checks with a spotlight. Our view to the bottom of the net, however, was sometimes obscured by turbid water. It was suspected by reviewers of this work that dolphin and turtles were caught in the net during the observer trips but the animals fell out during haulback and that, because from our point of observation, we did not see them. If this potential problem was real we think it was minor because during our frequent observation of the net prior to hauling we never observed a dolphin. Two turtles that were observed in nets were released alive in good condition.

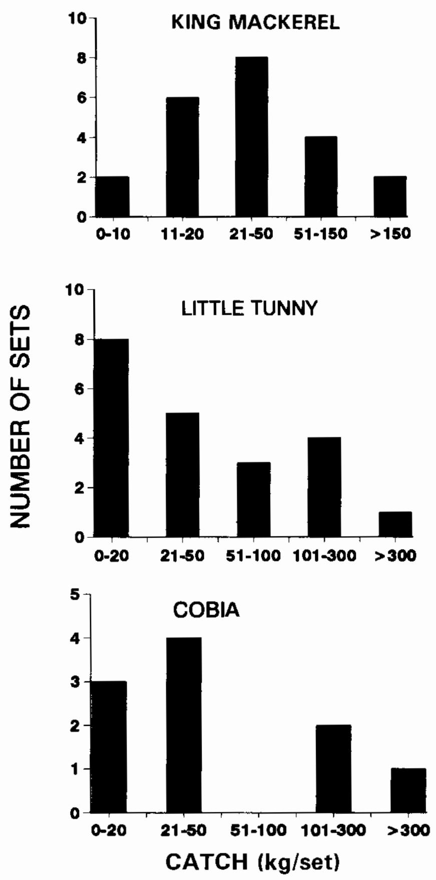

Figure 9.—Catch-frequency distributions by species for the three most abundant coastal pelagic species.

Conclusions

Based on presently available observer data, the shark fishery appears to have a much lower probability of causing mortality, per unit fishing effort, to bottlenose dolphin than does the swordfish fishery. Differences in the two fisheries (swordfish vs. shark) that possibly have bearing on the probability of causing mammal mortality are:

1) Areas fished are offshore along the continental shelf break in the northeast from Cape Hatteras to Block Island where several mammal species are abundant vs. inshore at water depths <25 m off Georgia and east Florida where fewer species are abundant, and

Table 7.—Weight-based discard ratios by area for sharks only and for sharks plus bycatch in the shark drift gillnet fishery.

Group and discard ratio (DR)	Area and disposition					
	Area 1		Area 2		Area 3	
	Kept (kg)	Disc. (kg)	Kept (kg)	Disc. (kg)	Kept (kg)	Disc. (kg)
Sharks	21,956	3,111	8,841	789	17,925	679
DR	0.14		0.09		0.04	
Bycatch	726	1,139	50	309	2,198	477
Sharks plus bycatch	22,682	4,250	8,891	1,098	20,123	1,156
DR	0.19	0.12			0.06	

Table 8.—Catch per unit of effort (CPUE) in kilograms caught per net-fishing hour by species and area, and for areas combined, for all observer data

Species	Kg caught per net-hour			
	Areas 1–3	Area 1	Area 2	Area 3
Blacknose	41.2	99.8	74.0	3.0
Atlantic sharpnose	38.6	5.3	7.5	63.6
Blacktip	37.9	81.4	53.3	11.9
Finetooth	11.2	32.8	4.2	2.0
Scalloped hammerhead	8.4	12.8	19.2	2.3
Bonnethead	5.5	12.6	3.5	2.4
Spinner	2.8	3.1	12.8	0.1
Great hammerhead	2.2	0.0	0.0	3.9
Other 4 shark species	1.1	0.9	4.7	0.3
Total (12 species)	148.9	248.7	179.2	89.5
King mackerel	3.0	0.1	0.3	5.1
Little tunny	1.8	0.1	0.6	2.9
Cownose ray	1.6	3.1	2.0	0.8
Crevalle jack	1.5	4.9	0.2	0.1
Cobia	1.4	3.0	0.4	0.1
Spotted eagle ray	1.3	3.3	2.1	0.1
Great barracuda	0.9	0.1	0.0	1.4
Tarpon	0.4	1.3	0.6	0.0
Other 17 nonshark species	1.0	0.1	0.3	1.6
Total (25 species)	12.9	16.0	6.5	12.1

Table 9.—Bottlenose dolphin mortalities suspected of being caused by human-induced fishing in relation to area and year along the U.S. Atlantic Coast (from Blaylock et al., 1995).[1]

Area	No. of animals	Year(s)	Statement
Va.	4	1992	Showed signs of entanglement with fishing gear. One of these was associated with pound net gear (K. Thornhurst, NMFS, personal commun.).
Va.–Md.	9	1993	Entangled in fishing gear, but gear type not reported (NMFS unpubl. data).
N.C.	22%	1993	Signs of interaction with fisheries (entanglement, net marks, missing appendages) were present in 22% of the bottlenose dolphin strandings investigated in North Carolina in 1993 (NMFS unpubl. data).
Atlantic states	20	1993	20 bottlenose dolphin mortalities which showed signs of fishing interaction were reported in the Atlantic states of the NMFS Southeast Region (Va., N.C., S.C., Ga., Fla.).
U.S. Atlantic-coastal stock	29	1993	A total of 29 bottlenose dolphins from the U.S. Atlantic coastal stock in the combined 1993 stranding records from both of the NMFS regions were reported to have shown indications of some sort of fishery interaction (NMFS unpubl. data). It is unclear whether the interactions contributed to the mortalities or occurred postmortem.

[1] Marine mammal stranding records (unpubl.) from the NMFS Southeast Region collected during 1988-93 showed that an average of 21 (CV = 0.30) stranded bottlenose dolphins from the area including North Carolina to the Florida Keys were discovered annually showing signs of human interaction ranging from net marks and entanglement to gunshot wounds and boat propeller strikes.

Table 10.—Estimated mortalities of bottlenose dolphin stocks (western North Atlantic Coastal and Offshore) by various fisheries and areas of the east coast of the U.S. (from Blaylock et al., 1995).

Area	Fishery	Comments
Coastal stock		
Northern Florida to New England	Atlantic menhaden	Annual incidental take of 1–5.
Atlantic Coast States	Coastal gillnet, otter trawls, purse seines, and haul seines	There are no estimates of mortality or serious injury available for these fisheries.
Georgia	Shrimp trawl fishery	One dolphin was recovered dead from a shrimp trawl in 1995.
Offshore stock		
Grand Banks south to Caribbean and Gulf of Mexico	Pelagic longline for groundfish and yellowfin tuna	No lethal takes during 1992–93 based on observer program. One live release was observed.
Primarily Georges Bank to Cape Hatteras	Atlantic large pelagic drift gill net	39 mortalities observed between 1989 and 1993. Mean annual estimated fishery-related mortality for 1989–93 was 53 (CV = 0.56).
From 35 N to 41 N and from 69 W to 72 W.	Atlantic swordfish/tuna/shark pair-trawl fishery	21 mortalities observed between 1991 and 1993. Estimated mean annual mortality attributable to fishery was 57 (CV = 0.51).
New England waters	New England groundfish multispecies trawl fishery	The average fishery-related mortality between 1989 and 1993 was 18 per year (CV = 2.17).
New Brunswick to Cape Hatteras	Mid-Atlantic mackerel and squid trawl fishery	Were reports of mortality in foreign fishery during 1977–88. No mortalities reported in log books from mackerel trawl fishery in 1990–92. No observer data available.

2) Large mesh sizes (stretched mesh from 18 to 24 in (46–61 cm)) for swordfish vs. smaller mesh sizes (5.5 to 12.0 in (14.0–30.5 cm)) for sharks.

Acknowledgments

We thank all the participating captains and crews (Ricky Cockran, Danny Malmsten, Thomas Watson, Brian Thomas, Kenny Evans, Donald Pinder, Mike Hands, George Johnson, Larry Bartrom, Junior Hardin, Frank Cook, and Chuck Carver) for help and cooperation during the survey and we especially thank captains Bruce Stiller, Jeff Alman, Mike Baker, James Cox, Carl Erickson, Ronnie Houck, and Wayne Winstead for assisting us in getting started and teaching us about the fishery. We also thank Bob Crane, C&W Fish Co., Port Salerno and Port Canaveral, Glen Black, Inlet Fisheries, Ft. Pierce, and Jim Bussey, Seafood Atlantic, Port Canaveral, for assistance in obtaining data and in locating captains.

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